



Status of NC Primer Demonstration & Transition

20 November 2014

Presented to:
ASETS Defense 2014

Presented by:
Julia Russell

AIR-4.3.4.2 Science & Technology Lead

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Topics of Discussion

- NC Primer Validation - Status
- AI-rich Primer Maturation
- M12-10 Internal Study
- Elevating Primer performance



NC Primer Validation





NC Primer Demos: Gloss Paint Scheme



Demonstration
COMPLETE

BUNO	Induction Date	Non-Chrome Primer Date	Delivery Date	Carrier Deployments
164497 (#642)	Jan. 28, 2009	Jun. 26, 2009	Aug. 17, 2009	No deployments ; transferred from VAW-120 to VAW-124 in June 2012
165648 (#603)	Apr. 10, 2009	Sept. 4, 2009	Oct. 7, 2009	<ul style="list-style-type: none"> • VAW-126: 1st Deployment aboard USS Truman (May – Dec 2010) • VAW-116: 2ND Deployment aboard USS Lincoln (Dec 2011 – June 2012) • VAW-116: 3rd Deployment aboard USS Vinson (Sept 2014-Present)
165650 (#600)	Jun. 16, 2009	Nov. 18, 2009	Dec. 23, 2009	<ul style="list-style-type: none"> • VAW-116: 1st Deployment aboard USS Lincoln (Sept 2010– Mar 2011) • VAW-112: 2nd Deployment aboard USS Stennis (Oct 2012-June 2013)
165811 (#654)	Oct. 26, 2009	May 9, 2010	Oct. 2010	<ul style="list-style-type: none"> • VAW-116: 1ST Deployment aboard USS Vinson (Dec 2011-June 2012) • VAW-116: 2nd Deployment aboard USS Vinson (Sept 2014-Present)

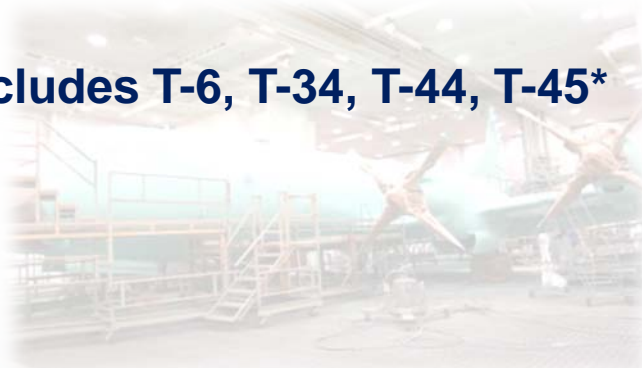


NC Primer Demos: Gloss Paint Scheme



NAS Meridean and NAS Kingsville *implemented* PPG-DEFT 02-GN-084 as a final prime on the OML of all USN trainers.

Includes T-6, T-34, T-44, T-45





NC Primer Demos: Gloss Paint Scheme

P-3C Demonstration is on-going...

- PPG-Deft 02-GN-084 demonstrated over CCC on OML
- Only one P-3C demonstrating NC Primer, A/C # 510
 - Primed Sept. 15, 2011





NC Primer Demos: Gloss Paint Scheme

As a result of the successful E-2C & Trainer demonstrations, NAVAIR drafted an authorization letter for the use of PPG-DEFT 02-GN-084:

“...PPG, Inc. – Deft 02-GN-084 is a non-chromate primer qualified to reference (f). References (g) and (h) contain results from both laboratory and outdoor exposure testing. References (i) through (l) contain results from an E-2C demonstration/validation on the OML of four aircraft. Based upon this data, NAVAIR authorizes the use of PPG, Inc. – Deft 02-GN-084 over conversion coatings qualified to MIL-DTL-81706, Type I, Class 1A when used in conjunction with a gloss topcoat qualified to MIL-PRF-85285.”

It is not authorized for use over non-chromate conversion coatings or extended to the use of PPG, Inc.–Deft 02-GN-084 with semi-gloss or camouflage (flat) topcoats qualified to MIL-PRF-85285, nor other application areas such as inner moldlines, radomes, components, weapons, or ground support equipment.

Once signed and released, each applicable Program will have the option to implement the primer at OEM and depot level.



NC Primer Demos: Camo Paint Scheme

H-46

- First full non-chromate coating system demonstration
- Hentzen 17176KEP (23377N, Ty II) over Henkel Alodine T5900 RTU (81706, Ty II)
- Three a/c primed with NC primer



TMS	BUNO	Non-Chrome Primer Date	Carrier Deployments
H-46	154856	Dec. 2010	HMM-268: 1st Deployment USS Makin Island (LHD 8) – Nov 2011 – June 2012
H-46	156474	Jan. 2012	None to date
H-46	153395	Aug. 2012	None to date



NC Primer Demos: Camo Paint Scheme

V-22

- Overpaint with Hentzen 17176KEP (MIL-PRF-23377N, Ty II) on composite components
- NC Primer implemented in LPS for OML & intermediate coats
- 20 a/c since May 2011





NC Primer Demos: Camo Paint Scheme

H-53

- Six a/c selected for demonstration of Hentzen 17176KEP

3 a/c @ each site

FRCE

- Full non-chromate coating stack-up demo
 - Hentzen 17176KEP over Henkel Alodine T5900 RTU (TCP)
- BUNO #:
 - #162517
 - #162487
 - #163075

3 a/c @ each site

FRCSW

- Non-chromate primer demo
 - Hentzen 17176KEP over CCC
- BUNO #:
 - #163076
 - #163080
 - #164859





NC Primer Demos: Camo Paint Scheme

F/A-18A-D

- 13 a/c selected for demonstration of PPG-Deft 02-GN-084 as induction primer and Hentzen 17176KEP as final prime over CCC

3 a/c @ FRCSE

FRCSE

- a/c #:
PM-05 (OCT 2013)
JC-22 (MAR 2014)
PM-07 (MAR 2014)

10 a/c @ FRCSW

FRCSW

BUNO #:	
164638	164678
164733	164215
165200	165195
164635	164734
165407	164877



NC Primer Validation

New aircraft (primer applied during production)

- **PPG-Deft 02GN098 on F-35B and F-35C aircraft**
 - No consistent ship environment until ~2015
- **PPG-Deft 02GN084 on MQ-8B Firescout test/LRIP aircraft**
 - a/c already operating from ship during testing
- **PPG-Deft 02GN084 on H-60R Seahawk production aircraft**
 - On low risk interior surface per SIC/UT risk assessment method
- **Hentzen 17176 Type II on EA-18G production aircraft**
 - Overcoat application during production final assembly, chromated primer on detail parts





Status of NC Alternatives

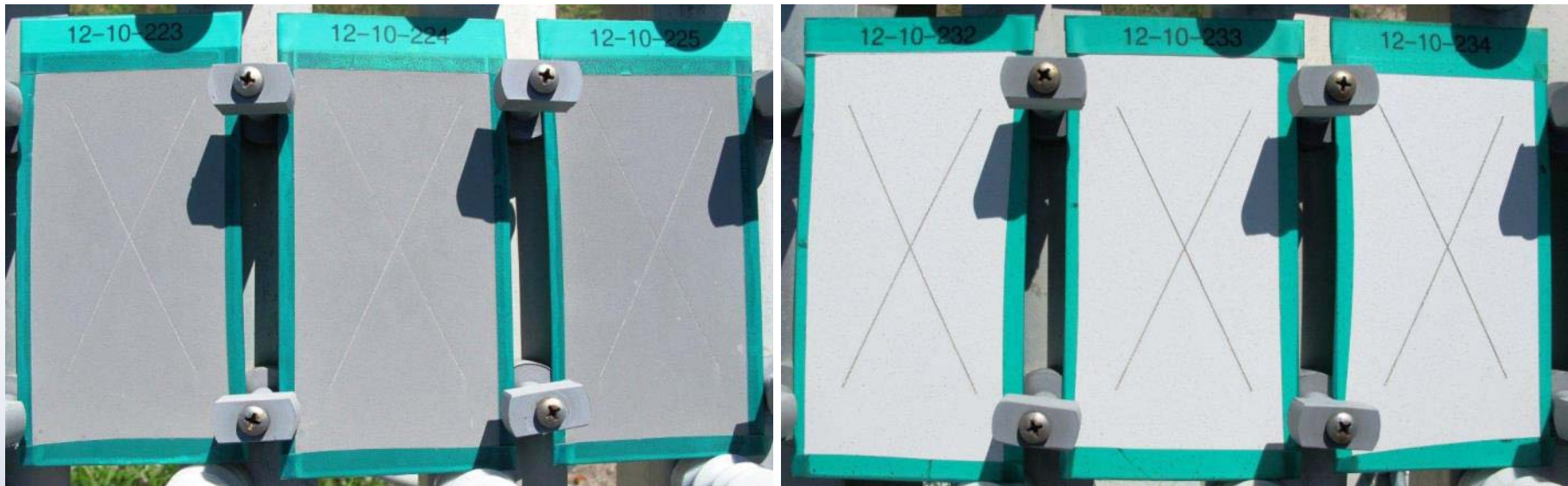
NC Primer R&D

- Metal-rich primers
 - Magnesium-rich primer: CRADA in place with Akzo Nobel to develop Mg-rich primer which meets NAVAIR requirements- kicked off in September 2013
 - Aluminum-rich primer: licensing underway for new NAVAIR technology. Primer designed for use on aluminum and steel, with potential as alternative to chromated primers on aluminum, MIL-PRF-53022 primers on mixed metals and zinc-rich primers on steel.
- Standard pigmented primers
 - None currently
- Linked Issue: Free isocyanates in topcoats
 - R&D underway to develop alternative aviation and CARC topcoats (SERDP & ONR)



Al-Rich Primer

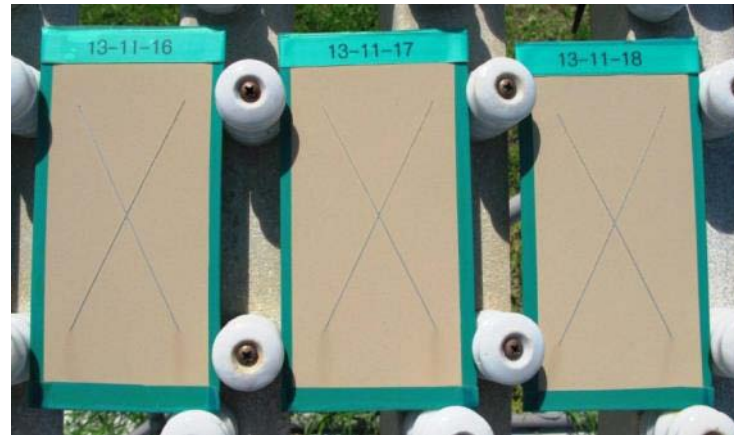
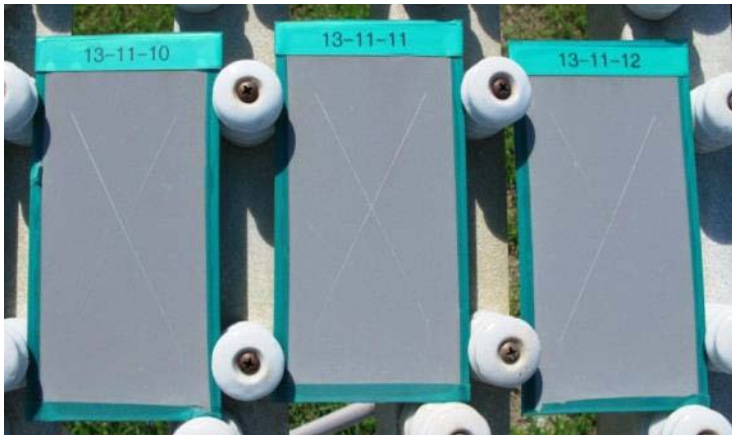
- Focus on exceeding performance of state-of-the art primers on aluminum (MIL-PRF-23377 Class C), mixed metals (MIL-DTL-53022 Type IV) and grit-blasted steel (zinc-rich primers)
- NAVAIR patented technology; licenses in place for U.S. and foreign markets
- Optimization of epoxy-based system continues while leading compositions are assessed in lab, on beach (KSC) and lead-the-fleet demos



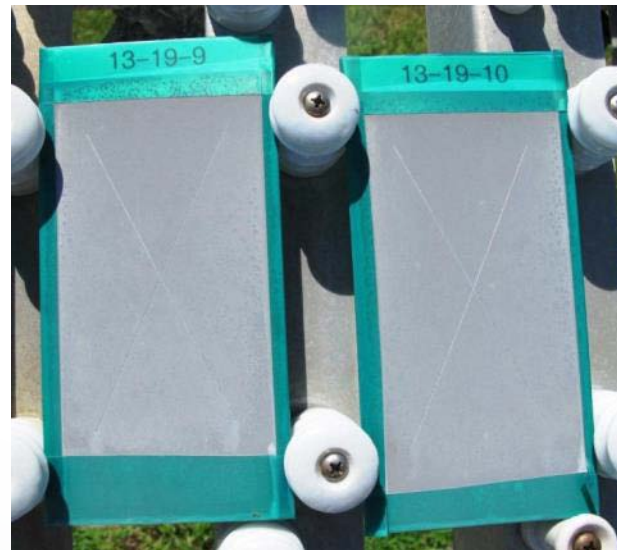
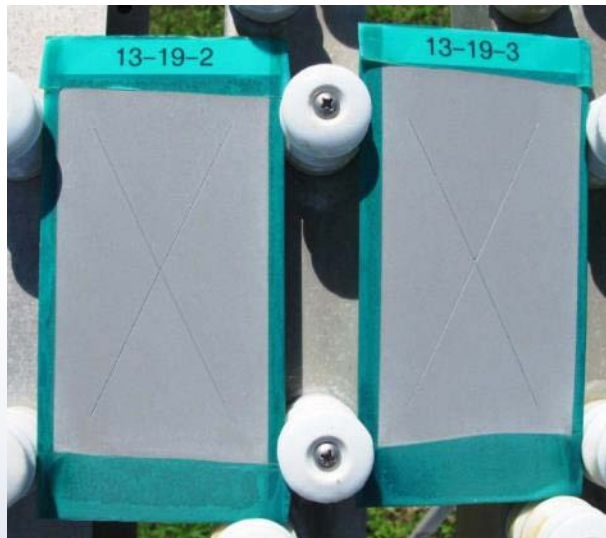
Al-rich primer (EP-7) on 2024-T3/Type I conversion coating, after 20 months at KSC test site. No degradation with (R) or without (L) topcoat. Topcoat is gloss white MIL-PRF-85285 Type I.



Al-Rich Primer



Al-rich primer (GP-FQ) on 7075-T6/Type II conversion coating, after **17 months** at KSC test site. No degradation with (R) or without (L) topcoat. Topcoat is Army CARC per MIL-DTL-64159.

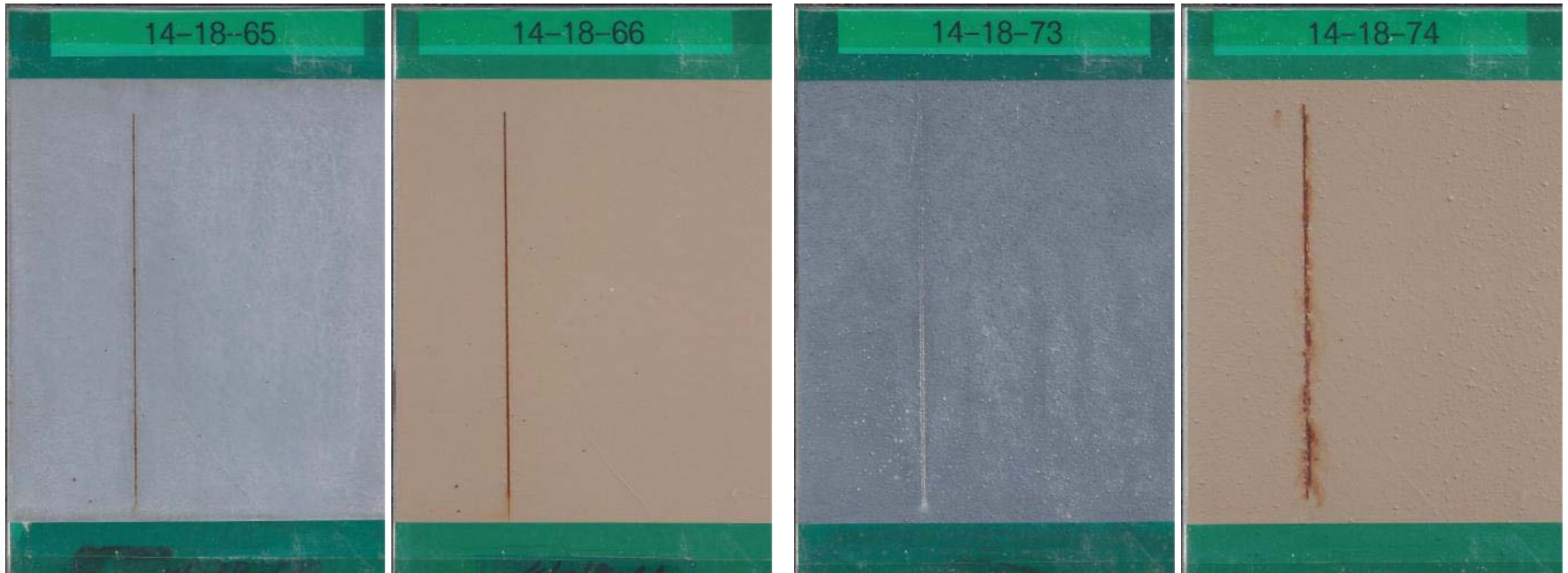


Al-rich primer on 2024-T3/Type II conversion coating, MP-DQ, (L) and LP-FQ, (R) after **13 months** at KSC test site. No topcoat.



Al-Rich Primer

Grit blasted steel, 4" by 6" by 1/16". Primers ~4 mils thick. After 21 cycles (3 weeks) in GMW 14872.



Al-rich primer (LP5-FQ) (L) and with MIL-DTL-53039 topcoat (R)

Sherwin Williams zinc-rich primer per MIL-DTL-24441 F.159 (L) and with MIL-DTL-53039 topcoat (R).

From test matrix 14-18, October 2014



Al-Rich Primer

Grit blasted steel, 4" by 6" by 1/8". Primers ~7 mils thick. After 21 cycles (3 weeks) in GMW 14872.



Al-rich primer (LP5-FQ) (L) and with MIL-DTL-53039 topcoat (C) and with MIL-DTL-53022 Type IV barrier primer and MIL-DTL-53039 topcoat (R)

From test matrix 14-17, October 2014



Al-Rich Primer

Galvanic protection

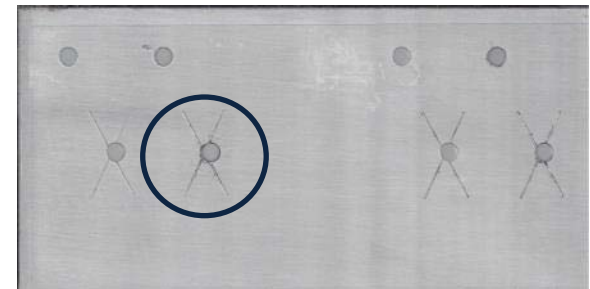
Primers on aluminum/TCP, ~1.5 mil thick, after 3 weeks/21 cycles in GMW 14872



Al-rich, XP-FQ



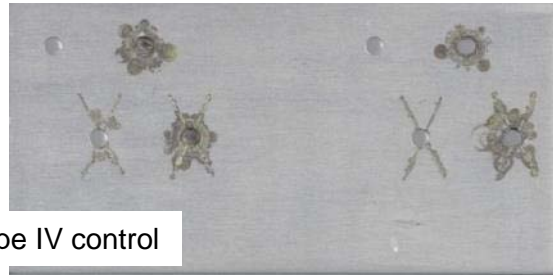
Formulation improvements



Latest results with newest Al-rich composition, LP5-FQ



-53022 Type IV control



-23377 C control



Fasteners removed

Coatings removed

From test matrix 13-25,
December 2013 and 14-18,
October 2014



Al-Rich Primer

- Cooperative R&D and Field Testing
 - NAVAIR
 - Kits being developed for touch up/wet install applications. Plan to assess at FRCs with potential field testing starting in FY15 at Cherry Point and Jax. Additional field testing planned for FY15-19 as part of NISE and ONR FNC projects. Focus is on equal or better performance relative to MIL-PRF-23377 Class C primers.
 - NAVSEA/Office of Naval Research (ONR)
 - Partner with Luna Technologies on new ONR Future Naval Capabilities project targeting heat sensitized 5XXX aluminum
 - Slow strain rate testing on sensitized 5083 shows that the Al-rich primer can greatly reduce loss of mechanical properties
 - Unprotected, highly sensitized 5083 loses 34% of strength in salt water, compared to lab air
 - with Al-rich primer, even with an artificial 1/8" gap in primer, loss in strength is only 3%
 - plan to assess impact on 7XXX and 2XXX aluminum in FY15/16 as well as effect on corrosion fatigue
 - NRL
 - Plan to assess Al-rich primer on steel for potential use in topside coating systems, with and without new 1K siloxane ship topcoat and new siloxane anti-skid coating
 - Navy facilities- plan to assess as alternative to zinc-rich primers
 - General: internal funding in place through at least 2019 to continue to mature the technology, including additional R&D on improved formulas. Any useful information we learn will be shared with licensees.



Al-Rich Primer

- Cooperative R&D and Field Testing
 - NASA
 - P-3B panels on aircraft for 2.5 years, primer only (inside) and primer and topcoat (exterior) (with Type II conversion coating). Positive results to date. Aircraft based out of Wallops Island, VA.
 - Based on positive results for P-3B and panels at KSC beach site, a new opportunity for field testing on a C-130 is available. Areas to be painted TBD. Visit to Wallops planned in late 2014 to work on plan forward for the P-3B and C-130.
 - Panel assessments underway which complement the P-3 and C-130 demos, as well as two new efforts:
 - NC coatings assessment with the European Space Agency (ESA). Al-rich primers included as potential alternative to chromated primers for aerospace applications (aluminum). Good pull-off adhesion and corrosion performance in initial assessment.
 - Panel assessment of Al-rich primer for potential use on grit blasted steel and grit blasted aluminum for potential use on facility steel and aluminum surfaces and upgrade to NASA coatings specification for facilities.
 - Air Force
 - ICBM Missile truck: plan to assess primer on grit blasted and Prekoted steel and aluminum panels with various fasteners. Positive performance on test panels could lead to field demo. Current primer is MIL-PRF-23377. Desire to go to NC and improve coating system performance on steel. Other similar applications have same need.
 - Army/USMC/ARL
 - Assessing for potential use on grit blasted steel as part of a new metal-rich primer specification being developed by ARL.
 - USMC planning for demo on ground vehicle(s) as an alternative to zinc-rich primer
 - AMCOM/G4 assessing on mixed metals as potential primer for missile systems and other assets with mixed metals as well as improved alternative to MIL-PRF-23377 Class N primers.
 - AMCOM assessing for potential field demos on missile system ground support equipment



M12-10

- Original purpose: Re-baseline primer performance
 - chromate & non-chromate
 - waterborne & solvent borne
- It also provided preliminary guidance as to corrosion test method that can differentiate primer performance



M12-10

NAVAIR evaluated qualified non-chromate
and chromate primers head-to-head
over CCC

Primer	Specification
PPG-Deft 44-GN-098	85582D, TY I, CL N
PPG EWDY048A	85582D, TY I, CL N
PPG EWAE118A	85582D, TY II, CL N
PPG-Deft 44-GN-007	85582D, TY I, CL C1
PPG-Deft 44-GN-008A	85582D, TY II, CL C1
PPG-Deft 02-GN-083	23377J, TY I, CL N
PPG-Deft 02-GN-084	23377K, TY I, CL N
PPG-Deft 02-GN-084N	23377K, TY I, CL N
Hentzen 16708TEP	23377J, TY I, CL N
Hentzen 17176KEP	23377J, TY II, CL N
PPG CA 7233	23377J, TY I, CL C2
PPG-Deft 02-Y-040B	23377J, TY I, CL C2



M12-10

Coatings were evaluated in four different corrosion test methods with different test durations and different rating intervals

Test Method	Test Duration	Rating Interval (hrs)
ASTM B117	2000 hours	500 hours
ASTM G85.A4	1000 hours	168 hours
GMW14872	120 cycles	20 cycles
Outdoor Beach Exposure, KSC	2 years	3 months



M12-10

Different Rating techniques employed at each site.

ASTM B117, GMW14872, and ASTM G85.A4 Rating System				
1st Digit - Scribe Appearance		2nd Digit - Undercutting		Size - 3rd Digit - Blistering
0	Bright and clean	0	No lifting of coating	0 = None Frequency
1	Staining, minor corrosion but no build up	1	Lifting or loss of adhesion up to 1/16" (2 mm)	1 = Very Small F = Few
2	Minor/moderate corrosion product build up	2	Lifting or loss of adhesion up to 1/8" (3 mm)	2 = Small M = Medium
3	Moderate corrosion product build up	3	Lifting or loss of adhesion up to 1/4" (7 mm)	3 = Small to Medium MD = Med. Dense
4	Major corrosion product build up	4	Lifting or loss of adhesion up to 1/2" (13 mm)	4 = Medium to Large D = Dense
5	Severe corrosion product build up	5	Lifting or loss of adhesion >1/2" (>13 mm)	5 = Large

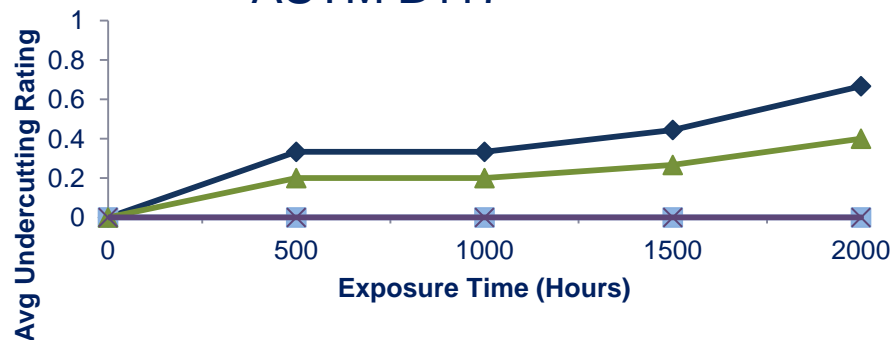
Outdoor Beach Exposure Rating System (ASTM D1654)

Representative Mean Creepage From Scribe		
Millimetres	Inches (Approximate)	Rating Number
Zero	0	10
Over 0 to 0.5	0 to 1/64	9
Over 0.5 to 1.0	1/64 to 1/32	8
Over 1.0 to 2.0	1/32 to 1/16	7
Over 2.0 to 3.0	1/16 to 1/8	6
Over 3.0 to 5.0	1/8 to 3/16	5
Over 5.0 to 7.0	3/16 to 1/4	4
Over 7.0 to 10.0	1/4 to 3/8	3
Over 10.0 to 13.0	3/8 to 1/2	2
Over 13.0 to 16.0	1/2 to 5/8	1
Over 16.0 to more	5/8 to more	0



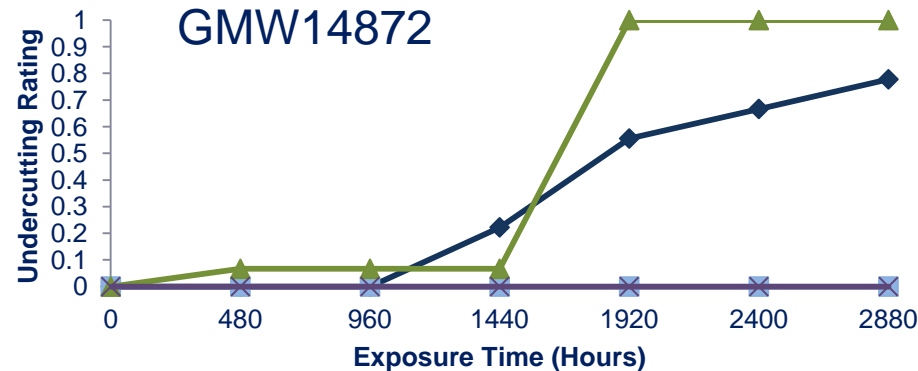
M12-10: Primer-Only Results

ASTM B117



◆ -85582 CL N □ -85582 CL C1 ▲ -23377 CL N × -23377 CL C2

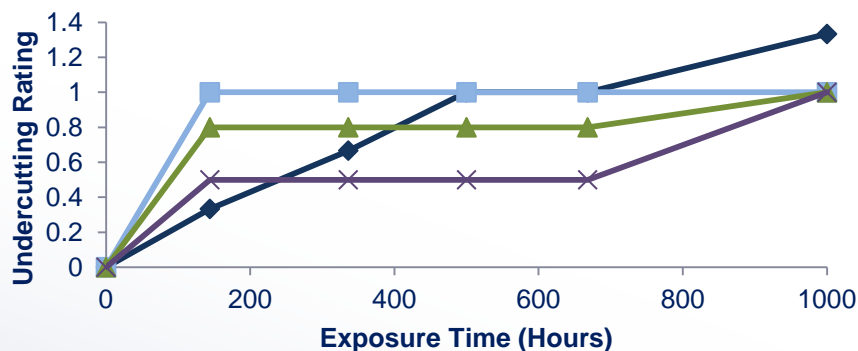
GMW14872



◆ -85582 CL N □ -85582 CL C1

▲ -23377 CL N × -23377 CL C2

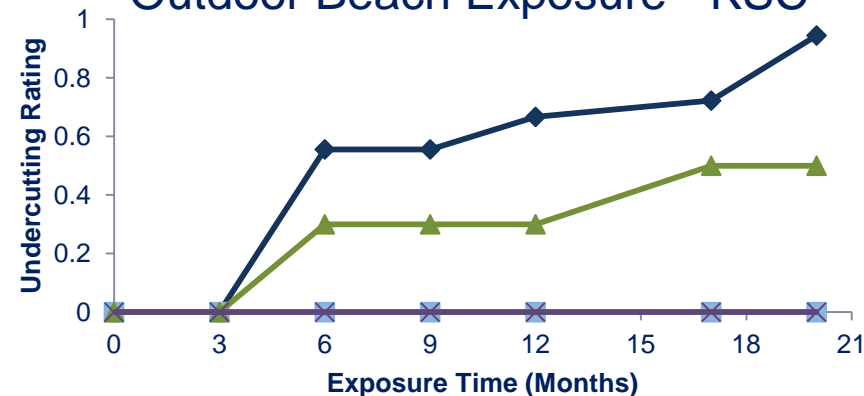
ASTM G85.A4



◆ -85582 CL N □ -85582 CL C1

▲ -23377 CL N × -23377 CL C2

Outdoor Beach Exposure - KSC



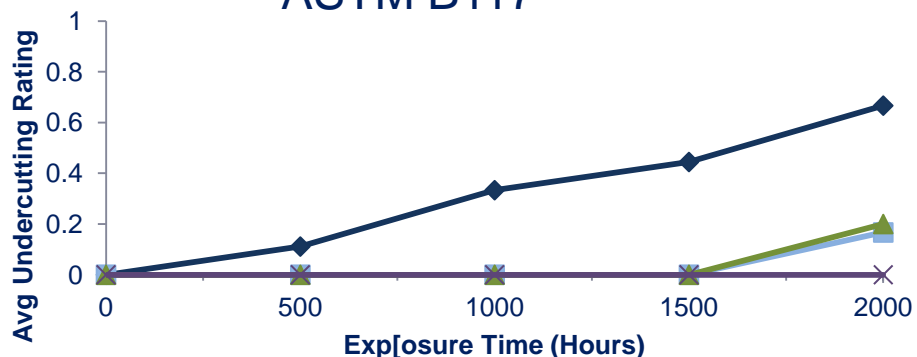
◆ -85582 CL N □ -85582 CL C1

▲ -23377 CL N × -23377 CL C2

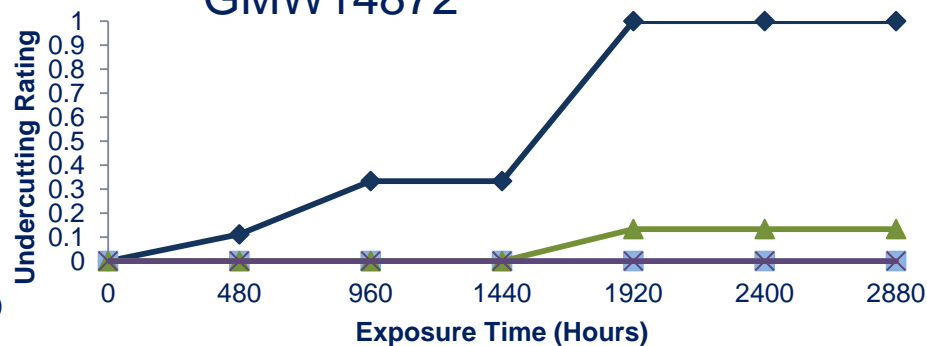


M12-10: Topcoated Results

ASTM B117

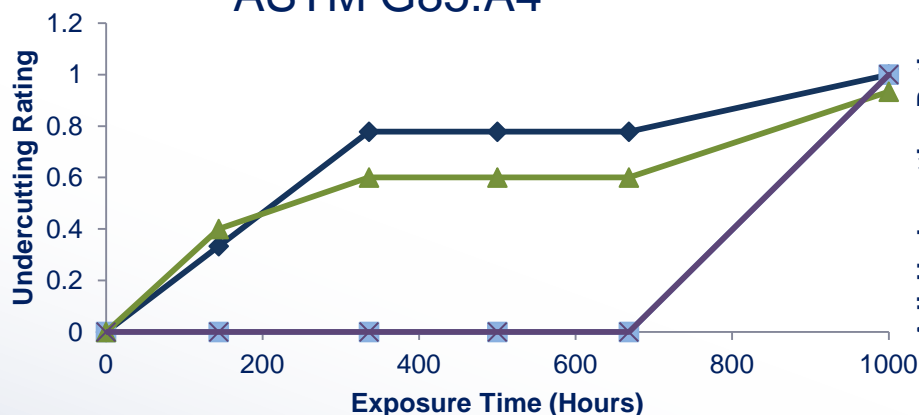


GMW14872

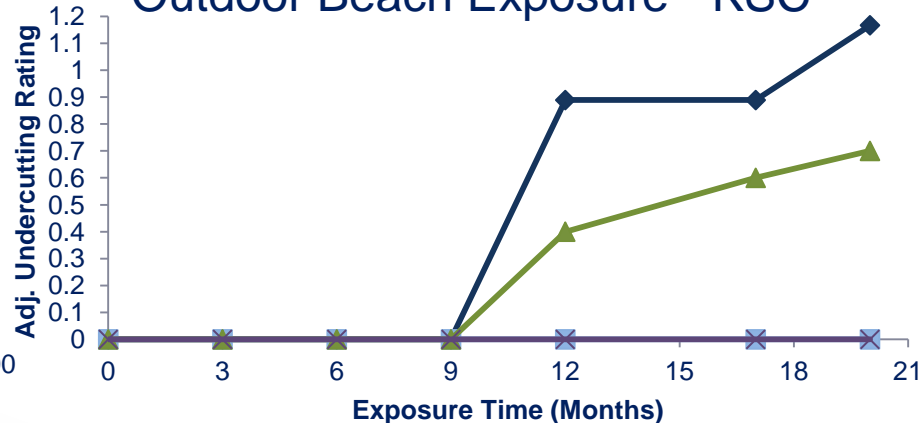


Legend for ASTM B117 and GMW14872:
-85582 CL N (dark blue diamonds)
-85582 CL C1 (light blue squares)
-23377 CL N (green triangles)
-23377 CL C2 (purple crosses)

ASTM G85.A4



Outdoor Beach Exposure - KSC



Legend for ASTM G85.A4 and Outdoor Beach Exposure - KSC:
-85582 CL N (dark blue diamonds)
-85582 CL C1 (light blue squares)
-23377 CL N (green triangles)
-23377 CL C2 (purple crosses)



M12-10: Results

- GMW14872 closely correlates to outdoor beach exposure testing
- Three step process for GMW14872 & Outdoor beach exposure:
 1. Minor/slow corrosion rate
 2. Steep increase in corrosion rate after approximately $\frac{1}{2}$ duration of test interval
 3. Plateau for corrosion performance
- ASTM B117 & ASTM G85.A4 illustrated a fairly constant rate in corrosion throughout the duration of the tests; **NOT RELEVANT** to outdoor environment



What now?

- Consider revising MIL primer specifications to better reflect performance in the natural environment
- Conduct additional studies to establish GMW14872 test requirement language for inclusion in specification
- Elevate primer performance



Elevating Primer Performance

- M12-10 provided comprehensive comparative data to allow for re-assessment of corrosion requirements
- Draw a minimum performance threshold using ASTM D1654 or other relevant corrosion rating specification
 - Ex: Require all non-chromates perform at a rating of 7 or higher; all chromates perform at a rating of 9 or higher
- Use new and revised requirements to clarify and elevate current corrosion performance



Elevating Primer Performance

- **Expanded laboratory validation (R&D efforts)**
 - **Galvanic interfaces-** planning to add galvanic requirement to primer specs
 - **Additional substrates:** anodized aluminum, magnesium, high-strength steel with cadmium, aluminum and zinc-nickel, composites
 - **Stress corrosion cracking and corrosion fatigue-** potential to add requirements to primer specs
 - **Al passivation-** considering adding passivation requirement to conversion coating spec



Elevating Primer/Topcoat Performance

Primer

1. Corrosion Performance
2. Lower VOCs
3. Flammability (increase flash point)
4. Chemical Strippability
5. Dry Time (-23377)
6. Fluid Resistance (Skydrol)
7. Solvent Resistance
8. Thickness Tolerance
9. Application Method
10. Packaging (1K and 2K)

Topcoat

1. Non-isocyanate
2. Lower VOCs
3. Flammability (increase flash point)
4. Chemical Strippability
5. Cleanability
6. Fluid Resistance (Skydrol)
7. Color Matching
8. Solvent Resistance
9. Thickness Tolerance
10. Application Method
11. Packaging



Questions?